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Memorandum

TO: BATA Oversight Committee

DATE: May 7, 2014

FR: Executive Director

W. I. 1256

RE: San Francisco-Oakland Bay Bridge East Span Maintenance Review Update

On May 6, 2014, Caltrans presented an issue memorandum to the Toll Bridge Program Oversight Committee (TBPOC) in regard to my request for an “itemized list of defects, flaws or irregularities that have the potential to require additional cost to maintain” the new eastern span of the San Francisco-Oakland Bay Bridge. (See Attached)

Caltrans identified only one issue as potentially requiring significant additional maintenance costs beyond what would normally be anticipated for a structure of this type: the A354BD bolts and rods installed on the steel portion of the new span. As reported last year, some A354BD rods used on Pier E2 to clamp down the bridge shear keys fractured when tensioned. The broken rods were completely abandoned, and the clamping force provided by the broken rods was replaced by the steel saddle retrofit that was completed in December 2013. Samples of the remaining similar A354BD rods and bolts used on the bridge are currently being tested and evaluated to assess their future status and disposition. As noted in the TBPOC July 8, 2013, report, potential future maintenance relating to these rods ranges from normal (no additional maintenance) to potential replacement. A recommendation on the disposition of these rods is anticipated in the fall of 2014.

Other items recently noted in the press were also discussed in the memorandum, including water intrusion in the roadway boxes, dehumidification, and the tower elevator. Caltrans indicated that items like water intrusion into the steel deck will be resolved before contract acceptance and will not require additional costs to maintain. Items like dehumidification may require more maintenance cost than typical, but were originally planned for in the design of the bridge.

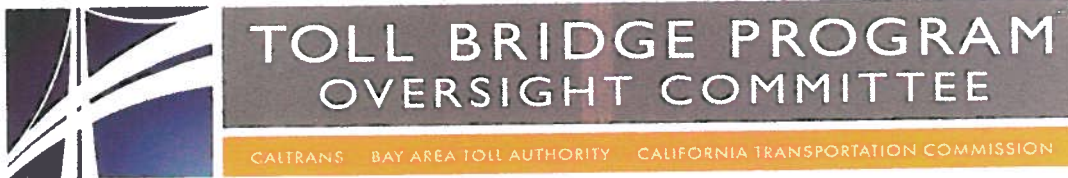
Staff is reviewing the memorandum and is proposing a peer review by other steel bridge owners through BATA’s association with the International Bridge, Tunnel, and Turnpike Association (IBTTA). IBTTA is the worldwide association for the owners and operators of toll facilities, including a number of major long span steel bridges like the Golden Gate Bridge, the George Washington Bridge in New York, and the Forth Crossing in Scotland. Staff has been in contact with IBTTA to identify individuals with long span steel bridge maintenance experience to review the Department’s findings.

We expect this peer review process will take a few months to complete, and will include site inspections of the new east span from end to end. Following completion of the review and further consultation with the TBPOC, we will return to this committee with a summary report of our findings including the estimated annual cost to maintain this new structure so that it achieves or exceeds its 150-year design life. Construction of the new east span has cost the region dearly in time and treasure. We need to do our utmost to protect this vital "lifeline" asset.



Steve Heminger

SH:pl



ISSUE MEMORANDUM

May 6, 2014

The Toll Bridge Program Oversight Committee (TBPOC) requested an "itemized list of defects, flaws or irregularities that have the potential to require additional cost to maintain". It is understood that "additional" is intended to mean maintenance significantly beyond what would normally be anticipated for a structure of this type. Only one issue meets this definition: A354BD bolts and rods installed on the main Self-Anchored Suspension Span (SAS) of the bridge. An extensive testing and evaluation process is underway to assess the status and disposition of these rods and bolts. As noted in the TBPOC July 8, 2013, report, potential future maintenance relating to these rods ranges from normal (no additional maintenance) to potential replacement. The testing and evaluation process is anticipated to result in recommended disposition in the summer of 2014.

The TBPOC request also called for the discussion of three issues: water in the Orthotropic Box Girder (OBG), water in bike path segments, and water in pre-stressing tendons. However, none of these three issues should require additional cost to maintain, and as discussed below, the first issue that has recently received much attention - water in the OBG - is not even properly characterized as a defect, flaw or irregularity.

There are a number of issues that have been highlighted by the media that, despite opinions issued by outside entities unfamiliar with the project, should not require any additional maintenance beyond what is normal for this structure. This is important context for this memo. Again, the "itemized list of defects, flaws or irregularities that have the potential to require additional cost to maintain" is a list of one item - the A354BD rods and bolts. All other items listed in this memo are present solely to indicate that they are challenges that have been or will be addressed or, alternatively, are items that will have additional maintenance but have been built as requested in accordance with the design recommendations established by the Bay Bridge Design Task Force.

The TBPOC request asked for a response to four specific questions, one of which is "When was the TBPOC was [sic] informed of the problem (if at all)?" TBPOC minutes capture approval or disapproval actions, but are not sufficiently specific to allow for a clear record of notice. That said, everything discussed in this memo has been previously discussed at past meetings that involve representatives from all three TBPOC agencies. Over the course of several years, the TBPOC has endeavored to address and resolve an array of critical issues concerning the State's toll bridge projects and, in particular, several relating to the construction of the new East Span of the San Francisco-Oakland Bay Bridge.

Additionally, staff from all three TBPOC agencies - the Bay Area Toll Authority (BATA), the California Transportation Commission (CTC) and Caltrans are involved in all aspects of the project on a daily basis and are in attendance at all significant project meetings. For example, BATA has a substantial presence at the project site with a number of oversight engineers, some physically located at Pier 7 and these

engineers regularly attend project meetings, review daily project documentation and provide independent reports and briefings to the chair of the TBPOC. The issue of water intrusion into the OBGs is a good example of the difficulty in responding to this question. The SAS project punch list has actively noted, for over a year, locations where water has been found. Resolution of the punch list item requires removal of water and surface rust and touch-up of primer if needed, as well as repairs to caulking/sealers if this is the means of water intrusion. The punch list has been available to BATA staff over the last year and is discussed in a weekly meeting that BATA attends.

The TBPOC request was recently modified to ask for a more comprehensive list of other issues that may be of interest relative to maintenance including significant planned maintenance items as well as the categorization of issues into construction-related issues, design-related issues, and normal issues not associated with either construction or design. However, there is overlap in many issues and this is noted below as a response to a fifth question which is "Is this construction-related, design-related, or normal?" The term "maintenance" is intended to cover upkeep and not work potentially resulting from the design safety evaluation event. The criterion "of interest" is clearly subjective and difficult to manage in the context of a summary level document as opposed to the large number of items included in punch lists and change order logs. Since issues such as "water in the OBG" were stated to be of interest to the TBPOC but never would have been identified by staff as such (since, as noted below, water in the OBG was anticipated by design), the TBPOC should consider its own review of the punch lists and change order logs to determine if there are other issues of interest to the TBPOC or others that should be addressed in a follow-up memo. These lists and logs are dynamic and any review by the TBPOC should take this into consideration.

There are a large number of normal maintenance activities such as maintenance of pavement, lighting, expansion joints, controls and security systems, etc. The intent of this memo is to touch on major items (major in terms of either dollars, media attention to date, etc.), whether normal, planned, resolved, or otherwise, in addition to the initially requested list. A more comprehensive discussion that will also include all standard maintenance items will be provided in a detailed East Span specific maintenance manual that is currently under development. It is also important to note that the maintenance manual is likely to be a dynamic document for several years, as any major, complex structure will have a "break-in" or "shake-out" period of several years where new, unanticipated issues are noted and addressed through the ongoing rigorous inspection process that has been conducted by construction to date and will be transferred to maintenance in the future.

I. "DEFECTS, FLAWS OR IRREGULARITIES THAT HAVE THE POTENTIAL TO REQUIRE ADDITIONAL COST TO MAINTAIN"

A354BD Rods and Bolts

The bolts that broke have been replaced with a retrofit and that work is complete. As for other bolts on the bridge that were built with similar ASTM standards, we are in the middle of a rigorous testing and analysis to confirm the integrity of those bolts, which have been under tension for up to three and one-half years and continue to perform as required.

The use of A354BD rods and bolts on the SAS has been under review since the failure of specific rods in March of 2013 and is the subject of an initial report issued by the TBPOC on July 8, 2013. A follow-up technical report will be issued in the summer of 2014 based on significant testing that is currently underway.

- 1 – The Department became aware of the failure of A354BD rods in March of 2013.
- 2 – The TBPOC was informed of this issue within days of the initial failures.
- 3 – The remediation strategy for the 2008 rods has been identified and implemented (the saddle/post-tensioning retrofit). The strategy for remaining rods and bolts will be determined at the conclusion of the current testing program.
- 4 – The cost of the remediation strategy for the 2008 rods is \$25 million. The cost of remediation, if any, for other rods and bolts will not be known until summer of 2014, when the current testing program has developed sufficient information to inform an appropriate strategy. The cost of testing required to develop this strategy, including both capital and support costs, is currently \$17.6 million.
- 5 – As the TBPOC preliminary report stated, the responsibility for the broken bolts was shared between the designer TY Lin/Moffatt and Nichol, the builder American Bridge/Fluor, and the owner, Caltrans. This issue is the result of a combination of design, construction and normal factors. This was discussed in some detail in the TBPOC July 8, 2013, report, although the involvement of national standards as well as BATA design oversight was not fully discussed in the report. In particular, the bolts that broke complied with national industry standards, suggesting that the ASTM standards themselves may need future revision. The information from our testing may assist with that process.

II. PLANNED ITEMS THAT MAY REQUIRE ADDITIONAL COST TO MAINTAIN

White Paint

White paint may require additional cost to maintain depending on aesthetic choices that are made.

- 1 – The Department has been aware of this issue since 1998.
- 2 – Two TBPOC agencies have been aware of this issue since 1998, and the TBPOC was aware of this issue immediately after the creation of the TBPOC in 2005 through its approval of the PS&E for the SAS in 2005.
- 3 – No remediation required.
- 4 – The cost to paint the SAS, based on 2006 dollars, is \$20 million.
- 5 – This issue is a planned (normal) issue.

Dehumidification

This bridge incorporated the advanced strategy of dehumidification to slow normal corrosion processes. This is one of the multiple layers of defense against corrosion. The five dehumidification units will require maintenance over the life of the bridge, and as dehumidification is not a usual element of a bridge, costs associated with maintenance could be viewed as additional.

- 1 – The Department has been aware of this since 2003 as a design element of the bridge.
- 2 – The TBPOC was aware of this issue immediately after the creation of the TBPOC in 2005 through its approval of the PS&E for the SAS in 2005.
- 3 – No remediation required.
- 4 – The cost to maintain these units is currently under review. The cost of the current system is \$1.5 million in 2006 dollars.
- 5 – This issue is a planned issue.

III. PLANNED ITEMS THAT SHOULD NOT REQUIRE ADDITIONAL COST TO MAINTAIN

Tower Elevator

An external elevator was included in the original design to assist with maintenance of the structure. This is a high-performance elevator, as it is intended to function after the functional evaluation earthquake. During construction of the SAS, the design of the elevator was revised to address comments from the Division of Occupational Safety and Health, and also to incorporate TBPOC requested changes such as the extension of the rise of the elevator to the highest point possible on the tower (made possible through elimination of the central architectural suspender cable) and increasing the visibility from the elevator by increasing the size of windows (a combination of an architectural and maintenance enhancement).

- 1 – The Department has been aware of this issue since 2003 as a design element of the bridge, and of changes as they have been implemented.
- 2 – The TBPOC was aware of this issue immediately after the creation of the TBPOC in 2005 through its approval of the PS&E for the SAS in 2005 and through its involvement with changes to the elevator to date.
- 3 – No remediation required.
- 4 – There should be no additional maintenance costs associated with this item beyond normal maintenance of an elevator of this type.
- 5 – This issue is a planned issue.

Suspender Ropes

Replacement of the suspender ropes is anticipated during the service life of the SAS. This is a normal and expected maintenance item for a suspension bridge (and therefore not additional). Suspender ropes have been replaced on the Golden Gate Bridge, for example. This occurred over a four year period beginning in 1972. Additionally, periodic checks of the cable band tensioning are a normal maintenance item for suspender ropes, similar to the process that occurred during erection.

- 1 – The Department has been aware of suspender rope replacement as a standard maintenance item since 1998.
- 2 – Two TBPOC agencies have been aware of suspender rope replacement since 1998, and the TBPOC was aware of this issue immediately after the creation of the TBPOC in 2005 through its approval of the PS&E for the SAS in 2005.
- 3 – No remediation required.
- 4 – There should be no additional maintenance costs associated with this item beyond normal maintenance of a steel bridge of this type.
- 5 – This issue is a planned issue.

Orthotropic Deck

Current national standards call for a 75 year life for decks of this type, and current design standards are believed to provide a life of up to 100 years for decks of this type. As the service life of the East Span is defined as 150 years, attention should be paid to fatigue of the deck. Some repair/replacement of portions of the orthotropic deck is possible during the service life of the bridge.

- 1 – The Department has been aware of possible deck repair/replacement as a standard maintenance item since 1998.
- 2 – Two TBPOC agencies have been aware of possible deck repair/replacement since 1998, and the TBPOC was aware of this issue immediately after the creation of the TBPOC in 2005 through its approval of the PS&E for the SAS in 2005.
- 3 – No remediation required.
- 4 – There should be no additional maintenance costs associated with this item beyond normal maintenance of a steel bridge of this type.
- 5 – This issue is a planned issue.

IV. NEW ITEMS THAT HAVE BEEN RECOMMENDED FOR CONSIDERATION THAT MAY REQUIRE ADDITIONAL COST TO MAINTAIN

Cable Traveler

A cable traveler is not necessary but will significantly facilitate SAS maintenance. The TBPOC may choose to initiate design and construction of the traveler as an element of the current capital program, or may defer this decision to the Department and BATA as an element of the bridge rehabilitation program.

- 1 – The Department has been aware of this issue since approximately 2003.
- 2 – This issue has been previously discussed with the TBPOC, but the date is uncertain.
- 3 – No remediation required.
- 4 – The cost to design and construct the traveler is under development, but should be assumed to be at least \$10 million in 2014 dollars.
- 5 – This issue is a planned issue.

Bridge Information Model (BRIM)

BRIM is envisioned to be a robust database that includes scanned copies of construction documents and a 3D model of the new span, all connected in a searchable database. This is a potentially valuable tool for both future maintenance and future capital projects. BRIM is a supplement/augmentation to the basic construction record.

- 1 – The Department began to develop this idea in 2013.
- 2 – This topic has been discussed with the TBPOC in 2013 and 2014, most recently at the March 2014 TBPOC meeting.
- 3 – No remediation required.
- 4 – The cost to build the database for the new East Span is between \$12 million and \$25 million in 2014 dollars. Additional support costs, in the order of \$200,000 per year will be required to maintain the database.
- 5 – This issue is a planned issue

V. ISSUES THAT HAVE BEEN OR WILL BE RESOLVED THAT WILL NOT REQUIRE ADDITIONAL COSTS TO MAINTAIN

Water Intrusion Into the Orthotropic Box Girder (OBG) Segments

Reducing moisture is part of general bridge maintenance and is not a safety issue. The bridge is designed to handle moisture, which is why it is coated inside with a protective primer and has drain holes and dehumidifiers. We take these precautions because water will always enter structures and we are prepared for that.

There are several thousand bolt and utility holes and other openings in the structure which all are potential conduits for water. Caulking, neoprene seals and other design measures were implemented to minimize water intrusion. Since water intrusion is expected, even with the best effort to control this, the interior of the bridge is primed and drainage channels exist to route water to weep holes at low points where the water can escape from within the OBG.

Work on the SAS bridge is not complete. In some cases primer may have been damaged during bridge erection, and some minor surface rust may have occurred due to the presence of water. This issue is well documented as an item the contractor must fix before the project is complete. The punch list has actively noted locations where water is found to allow for removal of surface rust and touch up of primer if needed, as well as repairs to caulking/sealers if this is the means of water intrusion. Observed water intrusion to date has ranged from condensation to slow drips, and in some instances, small puddles of water under the drips. The punch list has been available to BATA, CTC and Department staff over the last year and is discussed in a weekly meeting that BATA, CTC and the Department attends. In addition, staff is working to improve sealing of the OBG to further minimize water intrusion. Staff identified one detail (connection of barrier to deck stiffener) that can be improved to further reduce water intrusion. When all construction work is complete, we do not anticipate any additional, previously unconsidered maintenance work required and therefore no additional cost resulting from this temporary situation.

1 – The Department has been aware of this issue since 2013.

2 – Staff from all three TBPOC agencies has been provided with this information since 2013. All three TBPOC members became aware of this issue when media inquiries started in February 2014.

3 – Water intrusion will be limited through resolution of punch list issues, improved sealing at identified openings, and either a revised detail for the connection of the barrier rail to the interior deck stiffener or improved caulking or both.

4 – There would be an additional capital cost associated with revised details such as the connection of the barrier rail to the interior deck stiffener. The capital cost will be determined if such a detail is developed and implemented. There should be no additional maintenance costs associated with this item beyond normal maintenance of a steel bridge of this type.

5 – This issue was anticipated and is a combination of a construction issue and a design issue.

Water in the Bike Path Sections

Again, this situation developed during construction of the bike path and it has been addressed with a detailed survey to identify entry points for water, sealing of these entry points, and addition of drain holes in the bottom of bike path segments. A recent FLIR (forward looking infra-red) survey, taken after a significant rainfall, indicates that there is no water in the bike path segments and the remedial actions

were successful in addressing the issue. We do not anticipate any additional/unusual maintenance work resulting from this temporary situation.

- 1 – The Department has been aware of this issue since 2011.
- 2 – Staff from all three TBPOC agencies has been present at meetings when this was discussed in 2011 and later. TBPOC members became aware of this issue when media inquiries started in January 2014.
- 3 – Water intrusion and retention has been limited through revised details and improved sealing.
- 4 – Biannual FLIR surveys have been recommended, which would represent an annual maintenance cost of approximately \$5,000. However, the use of FLIR is under consideration as standard practice for enclosed and inaccessible steel structural elements.
- 5 – This issue is a combination of a construction issue and a design issue.

Concrete Prestressing Cavities

This issue was the result of a construction challenge that arose in 2004 and is common to segmental deck construction, cross duct grouting of pre-stressing tendon ducts. The potential for cross duct grouting resulted in extended periods in which tendons were installed but not grouted within the 1.2 miles of concrete skyway deck. Steps were taken to protect the tendons (vapor phase inhibitors). In 2006, a design engineer discovered water in ducts and some evidence of corrosion was observed. We initiated an exhaustive review of ungrouted ducts and installed tendons. A team of experts evaluated the condition of the steel tendons within the ducts using a digital borescope. In some cases tendons were removed and destructively tested. The conclusion of this survey was that tendons retained the required capacity to insure the desired performance standards. This situation was researched, analyzed and concluded in 2007. We also involved the Seismic Safety Peer Review Panel and the corrosion experts at the Turner-Fairbank Highway Research Center of the Federal Highway Administration who concurred with this conclusion.

- 1 – The Department has been aware of this issue since 2004, prior to the creation of the TBPOC.
- 2 – This issue was resolved in 2007. TBPOC members became aware of this issue in 2012 when media inquiries were made.
- 3 – No remediation required.
- 4 – There should be no additional maintenance costs associated with this item beyond normal maintenance of a post-tensioned concrete box girder bridge of this type.
- 5 – This issue is a construction issue.

Welding

This is a broad category including deck panel stiffener welding, deck panel segment assembly welding, and tower electroslag welding. In each case, specific issues were identified with welding operations, and defects were identified and repaired. Welding experts were engaged to address these issues, and the TBSSPRP reviewed all actions taken to address these issues.

- 1 – The Department has been aware of this issue during the period of 2008-the present.
- 2 – Staff from all three TBPOC agencies has been present at meetings when this was discussed. TBPOC members have been advised of these issues as they have been encountered and in some cases, such as the deck panel stiffener welding, were actively involved in managing the issue.
- 3 – All identified defects have been repaired. No remediation required.

- 4 – There should be no additional maintenance costs associated with this item beyond normal maintenance of a steel bridge of this type.
- 5 – This issue is a construction issue.

Deck Alignment

During initial welding activities connecting deck segments on site, the contractor had difficulty achieving required alignment tolerances for the entire width of the OBG segments. In some instances, and typically for a very limited length of the weld, alignment between segments was a few millimeters beyond specified tolerances. Analysis was performed to assess whether repair would be required to address this, and the analysis indicated that repair was not required and the bridge would perform to specified criteria. Additionally as experience with segment alignment increased, alignment improved to a point where almost all alignment was within specification.

- 1 – The Department has been aware of this issue since 2010.
- 2 – Staff from all three TBPOC agencies has been present at meetings when this was discussed in 2010 and staff from BATA participated in analysis of the issue. This issue was discussed with TBPOC members in 2010.
- 3 – No remediation required.
- 4 – There should be no additional maintenance costs associated with this item beyond normal maintenance of a steel bridge of this type.
- 5 – This issue is a combination of a construction issue and a design issue.

Suspender Ropes

Two items were noted during erection of the suspender ropes that do not impact maintenance but have been discussed with the TBPOC. Fabrication methods associated with the longer suspender ropes resulted in a very small number of instances of individual wire separation. This was determined to be the result of fabrication methods that, with respect to the longest suspender ropes requires the use of grips to pre-stretch ropes (a step in the fabrication process) and the grips used in this process created small indentations in a small number of wires that in turn led to wire separation of 5 wires (1 wire in 3 ropes and 2 wires in one rope, a total of 5 of 8,712 wires in the longer ropes).

Tension tests have already been conducted to assess the impact of such separations, and these tests established that there is absolutely no impact to the performance of the bridge. In addition, deformation was observed in a few wires in the shorter ropes, and this was addressed through realignment of the ropes through movement of suspender rope clamps. These issues have been presented to the TBSSPRP and the panel has concurred that the ropes meet project requirements.

- 1 – The Department has been aware of erection issues since late 2012.
- 2 – The TBPOC was aware of erection issues in 2012. Staff from all three TBPOC agencies has been present at meetings when all erection issues were discussed in 2012.
- 3 – No remediation required.
- 4 – There should be no additional maintenance costs associated with this item beyond normal maintenance of a steel bridge of this type.
- 5 – This issue is a combination of a construction issue and an industry issue.

VI. MEDIA ISSUES

Tower Foundation Piles

The Department was aware in 2008 that a testing technician had falsified data on projects not connected with the Bay Bridge, that the technician had been involved in some Bay Bridge testing, and that all Bay Bridge testing was found to be accurate. The Department became aware in late 2011 that one media outlet intended to create the impression that this was a Bay Bridge issue.

- 1 – The Department has been aware of this as a media issue since 2011.
- 2 – TBPOC members became aware of this issue when media inquiries started in late 2011.
- 3 – No remediation required.
- 4 – There will be no additional maintenance costs associated with this item.
- 5 – This issue is a media issue.

CONCLUSION

Everything discussed in this memo has been previously discussed at meetings that involve representatives from all three TBPOC agencies.

Again, many issues have been raised in the media that have been addressed, or will be addressed, before all construction work is completed on the East Span Replacement project. Issues addressed have been reviewed by the project's external experts and, in some cases, FHWA. As a result, we do not anticipate any additional resources will be required to maintain this bridge beyond what was already anticipated. We will certainly incorporate the resolution of these issues into our maintenance manuals for this bridge and our maintenance staff will be therefore more informed. There will be things that we will learn as we perform regular maintenance inspections on this complex bridge going forward. But nothing stands out as "new" at this point.